DOCUMENT RESUME

ED 225 819 SE 040 061

AUTHOR Carnegie, John W.
TITLE Lab Procedures. Sludge Treatment and Disposal Course #166. Instructor's Guide [and] Student Workbook.
INSTITUTION Linn-Benton Community Coll., Albany, Oreg.
SPONS AGENCY Office of Water Program Operations (EPA), Cincinnati, Ohio. National Training and Operational Technology Center.
PUB DATE Aug 80
GRANT EPA-900953010
NOTE 36p.; For related documents, see ED 224 718-720 and SE 040 060-062.
AVAILABLE FROM Linn-Benton Community College, 6500 SW Pacific Blvd., Albany, OR 97321 ($1. student workbook, $2. instructor's guide, cost per entire set of slide-tape, 1 student workbook and 1 instructor's guide is $75. per unit); EPA/Instructional Resources Center, 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212, prices from EPA are available upon request.
PUB TYPE Guides - Classroom Use - Materials (For Learner) (051) -- Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Instructional Materials; *Laboratory Procedures; Post Secondary Education; *Sludge; Teaching Guides; *Training Methods; *Waste Water; *Water Treatment

ABSTRACT

Laboratory tests used to determine status and to evaluate and/or maintain process control of the various sludge treatment processes are introduced in this lesson. Neither detailed test procedures nor explanations of how the tests should be applied to every unit are explained; this information is provided in other modules. The instructor's manual contains a brief description of the lesson, estimated presentation time, instructional materials list, suggested sequence of presentation, required reading list, reference reading list, lecture outline, narrative of the slide/tape program used with the lesson, and student worksheet (with answers). The student workbook contains objectives, glossary, descriptions of the laboratory tests for sludge treatment and disposal, worksheet, and list of treatment processes correlated with applicable laboratory tests and purpose of the tests. (Author/JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED225819

SLUDGE TREATMENT

and

DISPOSAL

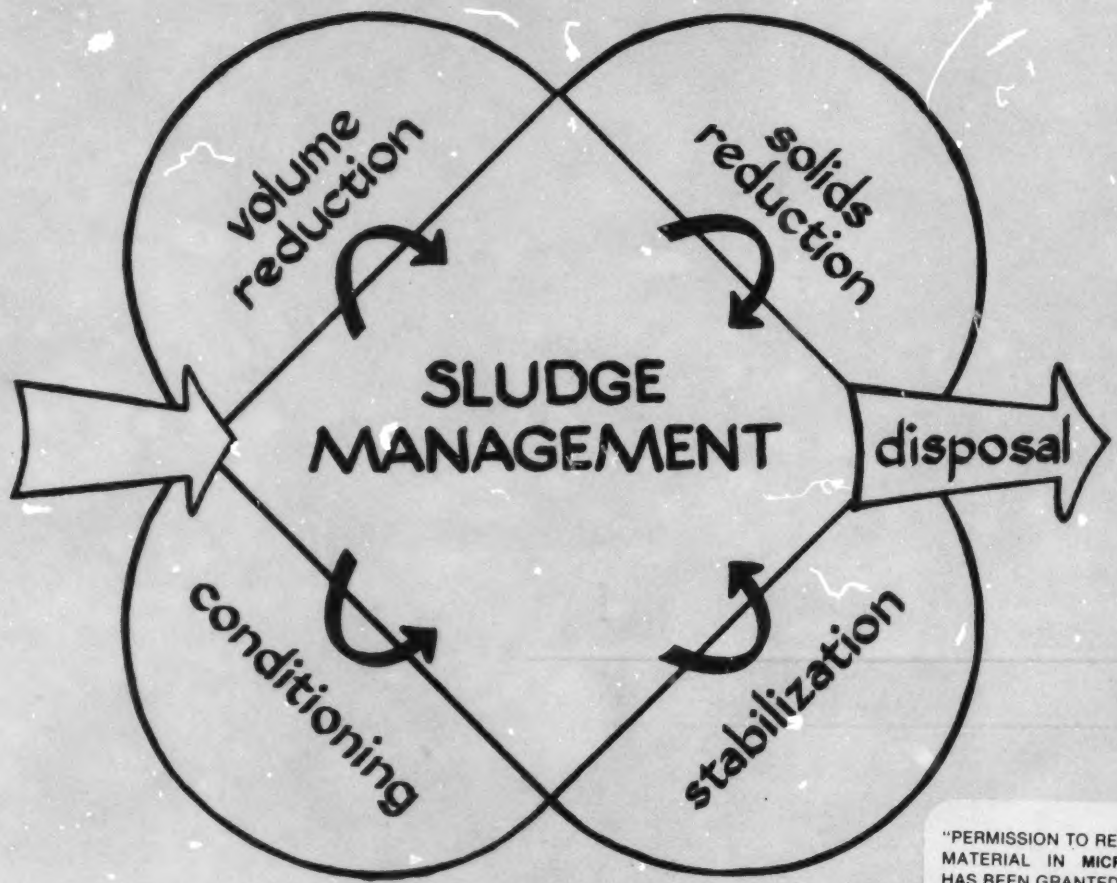
COURSE # 166

LAB PROCEDURES

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.
Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.



"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY
John Samson
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

INSTRUCTOR'S GUIDE

Prepared by
Linn-Benton Community College
and
Envirotech Operating Services

SE 040 061

LABORATORY PROCEDURES

Written By:
John W. Carnegie, Ph.D
Linn-Benton Community College
Albany, Oregon

Instructional Design:
Priscilla Hardin
Corvallis, Oregon

Technical Consultant:
Envirotech Operating Services
San Mateo, California

Project Director:
Paul H. Klopping
Linn-Benton Community College
Albany, Oregon

Project Officer:
Lynn S. Marshall
United States Environmental Protection Agency
National Training and Operational Technology Center
Cincinnati, Ohio

Developed Under:
EPA Grant #900953010
August, 1980

LAB PROCEDURES

CONTENTS

Subject	Page
Lesson Description	LP-1
Estimated Time	LP-1
Instructional Materials List	LP-1
Suggested Sequence of Presentation	LP-1
Required Reading	LP-2
Reference Reading	LP-2
Objectives	LP-3
Lecture Outline	LP-4
Narrative	LP-9
Answers to Worksheet	W-LP-1
Student Materials	S-LP-1 thru 13
	SW-LP-1 thru 2

LESSON DESCRIPTION

This lesson introduces the many laboratory tests used to determine status and to evaluate and/or maintain process control of the various treatment processes. It is not intended to explain the detailed test procedures nor to explain in detail how the tests should be applied to every unit process. Detailed explanation regarding specific processes is covered in other modules.

A general understanding of the unit processes would be recommended before beginning this module, although, not essential.

ESTIMATED TIME

Student preview of objectives	2 minutes
Presentation of slide/tape	14 minutes
Time to study text	10 minutes
Worksheet	10 minutes
Correct worksheet and Discussion	10 minutes

INSTRUCTIONAL MATERIALS LIST

1. Student text "Laboratory Testing Procedures for Sludge Treatment and Disposal"
2. Slide/tape set "Laboratory Testing Procedures for Sludge Treatment and Disposal"
3. Slide projector, 35mm
4. Tape player w/synchronization to projector
5. Screen

SUGGESTED SEQUENCE OF PRESENTATION

1. Assign students to read objectives in class.
2. Show slide tape program or lecture, using slides.
3. Ask students to review text material.
4. Assign worksheet.
5. Correct worksheet and open discussion.

REQUIRED READING

Student text material "Laboratory Testing Procedures for Sludge Treatment and Disposal."

REFERENCE READING

1. Process Design Manual for Sludge Treatment and Disposal, USEPA, EPA 625/1-79-011, Cincinnati, 1979.

2. Operations Manual; Sludge Handling and Conditioning, USEPA, EPA 430/9-78-002, Washington, D.C., 1978.

3. WPCF Manual of Practice No. 20, Sludge Dewatering, Water Pollution Control Federation, Washington, D.C., 1969.

4. Treatment and Disposal of Wastewater Sludges, P. Aarne Vesilind, Ann Arbor Science, Ann Arbor, 1979.

5. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA-AWWA-WPCF, Washington, D.C., 1981.

LAB PROCEDURES

OBJECTIVES

Upon completion of this lesson the student should be able to do the following:

1. Identify the major function or purpose of the sludge treatment disposal tests outlined in this module.

2. Given a description of the tests used for evaluating dewaterability, filterability, and thickening ability, identify tnem by name.

LECTURE OUTLINE

I. Laboratory tests to determine status and evaluate and/or maintain process control.

A. To determine dewaterability, filterability and thickening ability.

B. To maintain operational control.

C. To evaluate efficiency of treatment processes.

D. To evaluate and monitor health hazards and biological stability.

E. To measure nutrient value and heat value.

II. To determine dewaterability, filterability and thickening ability.

A. Applicable to such processes as vacuum filtration, centrifugation, gravity thickening and filter pressing.

B. Measures characteristics of sludge.

C. Measures improved characteristics due to conditioning.

D. Jar Test

1. Suitable for gravity thickening and flotation thickening.

2. Flocculation and settling observed in jars or beakers.

E. Buchner Funnel - Specific Resistance Test

1. Suitable for filtration processes.

2. Sludge added to a filter paper containing Buchner funnel and vacuum applied. Cake deposited on filter determined.

F. Filter Leaf Test.

1. Suitable for filtration processes.

2. Filter medium covers porous disc. Disc immersed in sludge and vacuum applied. Volume of cake determined.

G. Capillary Suction Time (CST)

1. Suitable for filtration processes.

2. Time required for liquid in sludge to travel 1 cm in a blotter paper.

III. To maintain Operational Control

A. Applicable to such processes as aerobic and anaerobic digestion and sludge lagoons.

B. Common wastewater lab test:

1. pH
2. Temperature
3. Volatile acids
4. Alkalinity
5. Dissolved oxygen
6. Methane
7. Settleometer

IV. To evaluate efficiency of treatment processes

A. Goal of most solids handling processes to reduce volume and mass of solids.

B. Measure the solids content before and after treatment.

C. Tests-also common wastewater lab tests.

1. % Solids (% moisture)
2. Total solids
3. Suspended solids
4. Volatile suspended solids
5. Centrifuge

V. To evaluate and monitor health hazards and biological stability

A. Applicable to land application and land fill.

B. Bacteriological Analysis

....total coliform, fecal coliform, total plate count, selected pathogens.

C. Heavy Metals Analysis

....toxic heavy metal measured by atomic absorption spectrophotometer.

D. Other toxic compounds

....organic compounds measured by gas chromatograph

E. Sludge Stability

1. Unstable sludge subject to decomposition and odor problems.
2. Oxygen Uptake
3. Volatile Suspended Solids
4. BOC
5. COD
6. Total Organic Carbon

VI. To measure nutrient value and heat value

A. Applicable to composting and land application.

1. Used to determine nutrient balance and necessary supplements.
2. Phosphorous
3. Nitrogen
4. Carbon

B. Applicable to incineration

1. Used to determine how well sludge will burn.
2. Calorific Value
   a. Chemical composition
   b. Empirical formula
   c. Volatile solids content
   d. Bomb calorimeter

VII. A look at four examples of how tests should be applied.

A. Gravity Thickening

1. Sampling points
   a. Influent sludge
   b. Thickened sludge
   c. Supernatant
2. Total Solids on % Solids
   a. Run on samples points a, b, and c.
   b. Monitors process efficiency
3. Suspended Solids and BOD.
   a. Run on sample point c.
   b. Measures load on side stream.
4. Settleometer
   a. Used on sample point a.
   b. Checks settling characteristics
5. Jar Test
   a. Used on sample point a.
   b. To check effects of conditioners.

B. Vacuum Filtration

1. Sampling points
   a. Influent sludge

b. Sludge cake

c. Filtrate

2. Total Solids or % Solids

a. Run of sample points a, b, and c.

b. Monitors process efficiency.

3. Suspended Solids and BOD

a. Run on sample point c.

b. Measures load on side stream.

4. Volatile Suspended Solids

a. Run on sample point b.

b. Used to determine organic content of sludge intended for composting or incineration.

5. Specific Resistance, Filter Leaf, Capillary Suction Time

a. Run on sample point a.

b. To check sludge characteristics.

c. To check effects of conditioners.

C. Aerobic Digestion

1. Sampling points

a. Influent

b. Digested settled sludge

c. Supernatant

d. Digester basin

2. Run on Digester Basin to assure balanced conditions

a. Temperature

b. pH

c. Dissolved oxygen

d. Alkalinity

e. Settleometer

f. Centrifuge

3. Total Solids and Volatile Total Solids

a. Run on sample points a and b.

b. Monitors stability and sludge solids reduction.

4. BOD, pH, and Suspended solids

a. Run on sample point c.

b. Measures load on side stream.

D. Land Fill

1. Sampling locations
   a. The sludge
   b. Observation wells
   c. Drainage ditch
2. Run on wells and sludge
   a. To monitor ground water around land fill.
   b. Heavy metals.
   c. Nutrients.
   d. Bacteria
   e. pH
3. Run on Drainage Ditch
   a. To monitor runoff during rainfall.
   b. Bacteria
   c. BOD
   d. pH
   e. Nutrients.

12

LABORATORY PROCEDURES

NARRATIVE

Slide #

1. This module discusses the laboratory tests used in normal operations of the sludge treatment and disposal processes. Step-by-step procedures are not presented, but rather a description of each test and its applicability is addressed.

2. The module was written by Dr. John W. Carnegie. Instructional development was done by Priscilla Hardin. Mr. Paul H. Klopping was Project Director.

3. In sludge treatment and disposal, laboratory tests provide information which helps operators make process control decisions. Using these tests, operators evaluate the characteristics of sludge, the effectiveness of treatment processes, and the potential environment impact of treated sludge. In this module these tests are grouped according to their application.

4. A group of process control tests guide the operation of specific sludge treatment processes.

5. Several tests measure conditioning effectiveness. These tests analyze the dewaterability of conditioned sludge and initiate needed changes in conditioning procedures.

6. Another group of tests helps evaluate process efficiency. Tests run on sludge before and after the treatment indicate the amount of water removed or the amount of solids reduced.

7. The environmental impact of sludge applied to land and landfills is evaluated by testing for microbial pathogens, toxic materials, and biological stability.

8. A final group of tests measures the nutrient and heat value of sludge.

9. Let's take a closer look at the tests in each of these groups, beginning with process control.

10. Biological solids handling processes require close operational control.

11. Laboratory tests used to assist in maintaining system balance are similar to those used in secondary treatment processes, such as activated sludge. Operators must continuously monitor biological systems to keep them running smoothly. These familiar tests are pH, DO, temperature, volatile acids, alkalinity, methane, and settleometer.

12. In solids treatment these tests are used to obtain operational data to control the biological processes of aerobic and anaerobic digestion and sludge lagoons.

13. Conditioning plays a major part in the successful operation of the dewatering process. Operators must determine the best conditioning methods to precede thickening and filtration units.

14. The jar test is best suited for evaluating flotation thickening, gravity thickening and centrifugation and for evaluating the effect of chemicals or heat conditioning on these processes.

15. In the test a series of jars or beakers is filled with sludge and dosed with different chemicals. The characteristics of the conditioned sludge are evaluated and the treatment process adjusted accordingly.

16. Three other tests are used to evaluate conditioning for the filtration processes. Capillary suction time test, specific resistance test and filter leaf test serve to evaluate conditioning prior to filtration processes such as filter presses, belt filters, and vacuum filters.

17. The specific resistance test measures the strength of conditioned sludge. Sludge is filtered under vacuum through filter paper in a Buchner funnel. The cake deposited per volume of filtrate is determined at that specific vacuum. Various chemical types and concentrations can be tested and evaluated.

18. The filter leaf test is another method of evaluating chemical conditioning procedures. The filter leaf is a flat disc over which is placed a filter medium. Vacuum is applied to the filter leaf and it is then immersed in conditioned sludge for a period of time. The volume of accumulated cake is then determined. Filter yield determination, as well as evaluation of filter media and conditioning chemical is possible.

19. The Capillary Suction Time or CST measures relative dewaterability. The CST is the time required for liquid in sludge to travel a given, known distance in a blotter paper. The lower the CST the lower the dewaterability.

20. Determination of process efficiency is, of course, important to good operations. In other words, is a sludge treatment process doing the job and how well?

21. The basic goal of most sludge treatment processes is to reduce the volume and mass of solids to a level which allows for economical disposal. This goal is best evaluated by analyzing solids before and after a particular treatment process.

22. The tests used to monitor process efficiency are familiar to most operators and are probably the most frequently performed tests throughout the plant. The tests run before and after treatment are percent moisture, total solids, suspended solids, volatile suspended solids, and the centrifuge test.

23. Percent moisture is determined by collecting a measured sample of sludge, drying the sample and weighing the residue. Calculation yields the weight of moisture driven off the sample in percent.

24. Total solids are the total dissolved and undissolved material in a sludge sample. A measured volume of sample is dried and the residue weighed. Calculation yields concentration of solids in mg/l.

25. Suspended solids are determined by weighing the amount of material captured during filtration. Volatile suspended solids are determined by ashing the filter from the suspended solids tests in a muffle furnace at about 600^{0} F and weighing the ashed filter. The weight lost is volatile solids.

26. Centrifuge test is the simplest operational test which can be done to assess concentration of solids by percent rather than weight. The solids are quickly and easily spun into a measurable pellet in the bottom of a centrifuge tube. Solids are read as percent by spin.

27. The environmental impact of sludge placed on land or in landfills must be continually assessed.

28. Sludge applied to land and landfills must not constitute a hazard to the surrounding area. Tests for bacteria, heavy metals, and toxic organic materials are used to monitor the impact of the sludge being placed in these areas.

29. The Fecal Coliform Test is used to evaluate the pathogenicity of the sludge.

30. Heavy metal content of the sludge can best be determined with atomic absorption flame spectrophotometry.

31. Toxic organics can be identified using gas chromatography.

32. In addition to these tests, sludge stability determinations should be made. The impact on the surrounding area is minimized if the sludge is low in organics and bacteria. Well stabilized sludge will not have an unpleasant odor.

33. The final two items, tests for nutrient and heat value, complete the list of recommended analyses.

34. Tests for nutrient value measure phosphorus, nitrogen, and carbon by standard laboratory methods.

35. A knowledge of the nutrient value of sludge is important when using it as a soil conditioner. Sludge does not contain adequate amounts of these nutrients to be considered a complete fertilizer. Therefore, the levels of phosphorus, nitrogen, and carbon must be known in order to supplement the sludge properly.

36. Likewise, when sludge is composted it must have a balance of nutrients present. Supplemental nutrients may be required to optimize the stabilization process in the composting pile.

37. The most common method used to determine heat value is the volatile total solids test. By assessing the heat value of sludge it is possible to determine how well the sludge will burn and how much auxiliary fuel must be added to the incinerator.

38. All of the methods we have discussed are valuable aids to operation of treatment processes. Most can be done easily by operations without sophisticated laboratory equipment. Some, however, require trained technicians and special instruments.

39. Detailed explanations of how the tests are applied to the operation of the various sludge treatment processes are presented in the specific unit process modules. Refer to these modules to develop from these tests a list of those to be used with your sludge treatment system.

40. Detailed procedures for running these tests can be found in the 15th edition of Standard Methods or the Laboratory Procedures for Operational Control developed by Linn-Benton Community College to supplement this course.

41. In this brief overview of tests to be used with sludge treatment processes, we discussed their use based on five operational goals which they serve.

42. A group of tests were identified which provide data used to maintain smooth operation of biological sludge treatment process.

43. Operators use a second group of tests to evaluate conditioning effectiveness where sludge is conditioned prior to dewatering processes.

44. Tests that measure solids concentration are run before and after process units to measure process efficiency.

45. Another group of tests provide data used to predict the environmental impact of sludge applied to land and landfill.

46. And finally, the nutrient value and heat value of sludge is measured to evaluate the need for supplemental nutrients when placing sludge on land or in composting operation and the need for supplemental fuel for sludge incineration.

47. Analytical and operational control testing provides valuable data to support plant operation. In addition, test results become a permanent record to support management decisions.

WORKSHEET

1. Match the following test descriptions with their name.

2	a. Sludge added to a Buchner funnel containing a filter paper.	1. Jar test
3	b. Filter medium cover porous disc to which vacuum is applied.	2. Specific resistance test
1	c. Flocculation and settling observed in beakers.	3. Leaf test
4	d. Time required for liquid to travel 1 cm in a blotter paper.	4. Capillary suction time (CST)

2. Match the following laboratory testing procedures with the major function or purpose in operating sludge treatment and disposal.

1	a. Jar test	1. To determine dewaterability, filterability and thickening ability
2	b. pH	2. To maintain operational control.
3	c. Total solids	3. To evaluate efficiency of treatment processes.
4	d. Toxic organic compounds	4. To evaluate and monitor health hazards and biological stability.
4	e. Heavy metal analysis	5. To measure nutrient value and heat value.
1 or 2	f. Settleometer	
2 or 4	g. Oxygen uptake	
1	h. Filter Leaf Test	
2	i. Dissolved oxygen	
3	j. Suspended solids	
1	k. Capillary Suction Time	
2	l. Methane	
5	m. Calorific value	
2	n. Alkalinity	
4	o. Volatile suspended solids	
1	p. Specific resistance test	
4	q. BOD, COD	
4	r. Bacteriological Analysis	
3	s. % Solids	
2	t. Volatile acids	

5 u. Phosphorous

3 v. Centrifuge

5 w. Total Organic Carbon

5 x. Nitrogen

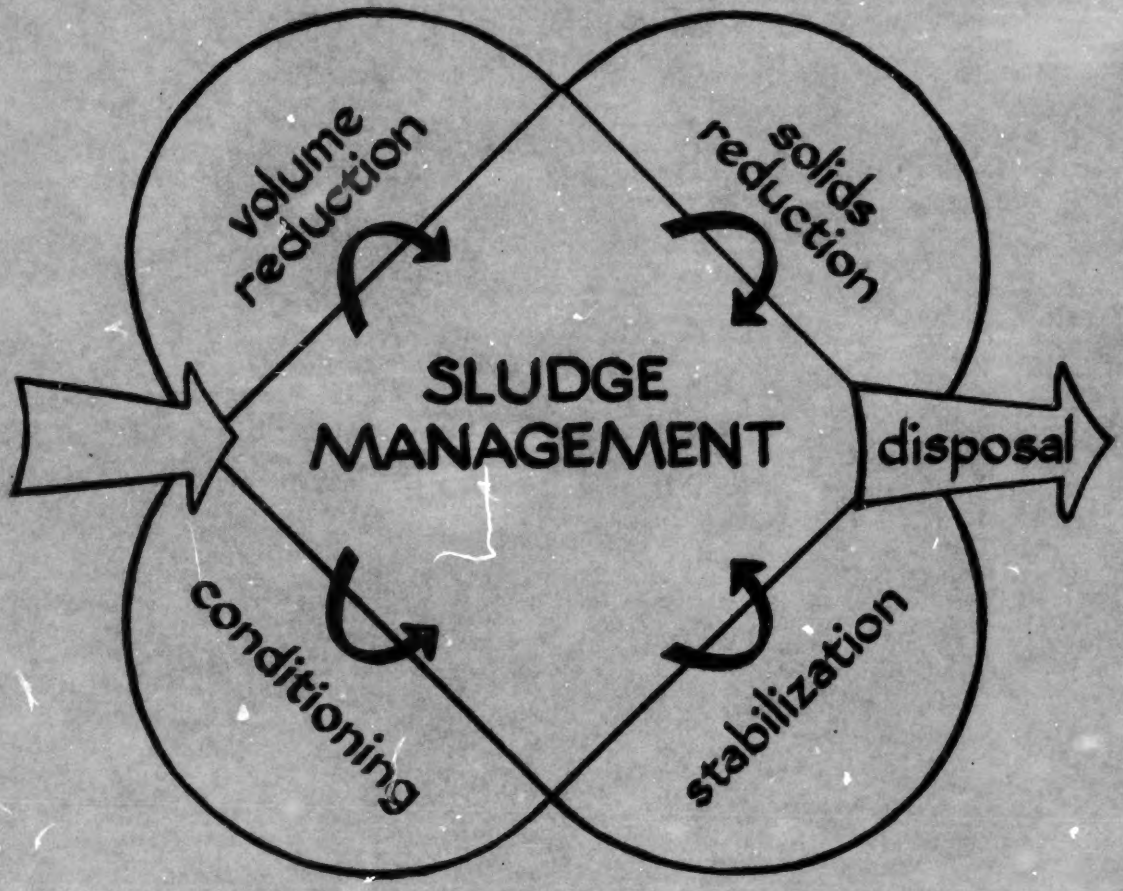
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

LAB PROCEDURES



STUDENT WORKBOOK

Prepared by
Linn-Benton Community College
and
Envirotech Operating Services

SE 040 061

LABORATORY PROCEDURES

Written By:
John W. Carnegie, Ph.D
Linn-Benton Community College
Albany, Oregon

Instructional Design:
Priscilla Hardin
Corvallis, Oregon

Technical Consultant:
Envirotech Operating Services
San Mateo, California

Project Director:
Paul H. Klopping
Linn-Benton Community College
Albany, Oregon

Project Officer:
Lynn S. Marshall
United States Environmental Protection Agency
National Training and Operational Technology Center
Cincinnati, Ohio

Developed Under:
EPA Grant #900953010
August, 1980

LAB PROCEDURES

CONTENTS

Subject	Page
Objectives	S-LP-1
Glossary	S-LP-2
The Purposes and Functions	S-LP-3
Four Examples of Test Application	S-LP-7
Appendix A	S-LP-10
List of Processes and Tests	
References	S-LP-13
Worksheet	SW-LP-1

LAB PROCEDURES

OBJECTIVES

What will you learn from this lesson?

Upon completion of this lesson you should be able to do the following:

1. Identify the major function or purpose of the sludge treatment and disposal tests outlined in this module.

2. Given a description of the tests used for evaluating dewaterability, filterability, and thickening ability, identify them by name.

LAB PROCEDURES

GLOSSARY

Cake - Semi-dried sludge from dewatering processes.

Filtrate - The liquid separated from sludge in filtration type dewatering processes.

Filter medium - Porous material through which sludge is filtered.

Nutrient - A substance which is required to support living plants and organisms. Major nutrients are carbon, hydrogen, oxygen, sulfur, nitrogen and phosphorus. Nitrogen and phosphorus are difficult to remove from wastewater by conventional treatment processes because they are water soluble and tend to recycle.

Pathogenic organisms - Bacteria or viruses which can cause disease (typhoid, cholera, dysentery). There are many types of bacteria which do not cause disease and which are not called pathogenic. Many beneficial bacteria are found in wastewater treatment processes actively cleaning up organic wastes.

LABORATORY TESTING PROCEDURES
for
SLUDGE TREATMENT AND DISPOSAL

This module presents a brief overview of the laboratory tests used for sludge treatment and disposal. The test procedures are presented by their intended function and applicability to the various sludge treatment processes. It is recommended that this module be preceded by some introductory material about the unit processes.

This module was developed by Dr. John W. Carnegie. The instructional development was done by Priscilla Hardin. Paul H. Klopping was the project director.

PROCESS CONTROL TESTING

As with other wastewater treatment processes, there are laboratory tests which can and should be used to determine status and to evaluate and/or maintain process control for the various sludge treatment and disposal processes.

DEWATERABILITY, THICKENING

There are a number that can be used to determine the dewaterability, filterability, and thickening ability of sludge and how various conditioning processes can improve these characteristics.

SPECIFIC PROCESS TESTS

There is a group of tests which is used to maintain operational control of specific processes; such as, aerobic and anaerobic digestion.

EFFICIENCY MEASUREMENTS

There is a group that is used to evaluate the efficiency of the various volume and solids reduction processes by measuring solids

content before and after the process.

HEALTH

The health hazards and biological stability of sludge to be applied to land and landfill can be evaluated.

NUTRIENTS & HEAT VALUE

And the nutrient and heat value of sludge can be determined.

Let's take a closer look at each of these groups. The efficiency of sludge handling processes; such as, vacuum filtration, centrifugation, gravity thickening and filter presses depends on the dewaterability, filterability, or thickening ability of the sludge.

CONDITIONING
- *jar test
- *specific resistance
- *filter leaf
- *capillary suction time

Conditioning is often used to improve these characteristics. These characteristics can be monitored and evaluated and the effects of conditioning process evaluated by using the following tests: the jar test, the Buckner funnel adaptation of the specific resistance test, the filter leaf test, and capillary suction time.

JAR TEST
- *evaluate floc

The jar test is best suited for evaluating gravity thickening and flotation thickening and the effect of chemical or heat conditioning on these processes. In the test a series of jars or beakers are filled with sludge and dosed with different concentrations of conditioner chemical. After, flocculation evaluation is made on the basis of floc characteristics and settling rate.

SPECIFIC RESISTANCE
- *filter cake vs. filtrate

The specific resistance test is most commonly used with the filtration processes. The test is run by putting sludge onto a filter paper

in a Buchner funnel and applying a vacuum. The cake deposited per volume of filtrate is determined at that vacuum. The test measures the ability of the sludge to resist passing through the filter. The effect of conditioners can, of course, be evaluated.

FILTER LEAF
*filter yield

Another test commonly used on filtration processes is the filter leaf test. The "filter leaf" is a round porous disc over which is placed a piece of filter medium. Vacuum is applied to the disc and it is then emersed in a beaker of sludge for a set period of time. The volume of caked sludge is then removed and weighed. Filter yield can be determined and conditioners evaluated.

CAPILLARY SUCTION TIME
*filterability
*like specific resistance

Capillary suction time, or CST, can also be used to measure filterability. The CST is the time required for liquid in sludge to travel 1 cm in a blotter paper. High CST value means poor filterability. Because it is quite simple, the CST is commonly used by operators and can approximate the specific resistance test.

PROCESS CONTROL TESTS

A couple solids handling processes are biological processes which require close operation control to balance the process. Anaerobic and aerobic digestion and sludge lagoons to some extent are such processes.

These common operational tests include pH, temperature, volatile acids, alkalinity, dissolved oxygen, methane and settleometer.

These are tests that are familiar to most operators since they are used throughout

the treatment plant.

VOLUME & MASS REDUCTION

The essential goal of each solids handling process is to reduce the volume and mass of solids to a level that can be economically disposed of. A number of tests are used to evaluate the extent of the volume and mass reduction.

These tests are also familiar to most operators since they are commonly used on plant influent and effluent. Used on the sludge before and after a treatment process they will give the extent of volume or mass reduction which occured in the process. The centrifuge can be used to quickly estimate the solids concentration of most all sludges.

Sludge applied to land application and land fill must not constitute a health hazard to the surrounding area. A number of tests help evaluate the effects that sludge might have on the soil and water near the area of application.

BACTERIOLOGY

The sludge can be tested for bacteriological content. Total coliform, fecal coliform, total plate count, or selected pathogenic organisms can be monitored.

HEAVY METALS

Sludge tends to accumulate metals, some of which may be toxic heavy metal; such as lead or mercury. Sludge can be tested using the atomic absorption spectrophotometer to determine the heavy metal concentration.

TOXICS

Other toxic compounds, such as slowly or non-degradable organic compounds can be monitored

in sludge using the gas chromatograph.

SLUDGE STABILITY

The stability of sludge applied to land should be continuously monitored. Unstable sludge is subject to additional bacteria decomposition which may cause unacceptable odors or support pathogenic organisms. Again, these are common tests to most treatment plant operations.

NUTRIENTS

When sludge is applied to land and when it is composted its nutrient content is important. Many times supplements must be added to sludge applied to land. Composting sludge requires a specific balance of nutrients.

The Phosphorous, Nitrogen, and Carbon content can all be analyzed using conventional methods.

HEAT VALUE

The heat value or calorific value of sludge is used to determine how well the sludge will burn in an incinerator and how much auxiliary fuel will be required. The calorific value can be determined by calculations based on the chemical composition and empirical formulas, by the volatile solids content, or by a bomb calorimeter.

Since more detailed explanations of control and monitoring tests are included with each unit process module, let's look at only a couple processes to see how tests can be used.

An Example: Gravity Thickening

SOLIDS

SETTLEABILITY
*Settleometer

Gravity thickening is a good example. The gravity thickener has three sample points: influent sludge; thickened sludge; supernatant.

Total solids or % solids should be run on influent, thickened sludge, and supernatant to monitor efficiency. The centrifuge can also be used to determine solids. Suspended solids and BOD run on supernatant measure the load in the side stream. The settleometer can be used to check settleability along with the jar test to check the effect of conditioning on settleability.

Another Example:

Vacuum Filtration

*% solids
*sus solids, BOD
*COD, TOC
*volatile solids
*specific resistance, filter leaf, capillary suction time

The vacuum filter is a good example of filtering processes. The vacuum filter also has three sample points: influent sludge; sludge cake; filtrate.

As with the gravity thickener, total solids on % solids should be run on influent, sludge cake, and filtrate to monitor the dewatering efficiency. Suspended solids and BOD run on the filtrate measure the side stream load. COD or Total Organic Carbon, can be substituded for BOD.

Volatile suspended solids can be run on the sludge cake to determine organic content if intended for composting or incineration. Specific resistance, filter leaf, or capillary suction time can be used to monitor dewaterability of influent sludge and to check the effects of conditioning.

BIOLOGICAL PROCESS CONTROL

The aerobic digester represents a process requiring a continuous control of bacteriological growth. There are four sample points: influent; digested settled sludge; supernatant and in the digester basin.

Temperature
pH
DO
Alkalinity
Settleability
Solids

Temperature, pH, DO, alkalinity, settleometer, and centrifuge should all be run on the digester basin to assure balanced and consistent growth conditions.

Total solids and volatile total solids should be run on the influent and the digested sludge to maintain stabilization and sludge solids reduction. BOD, pH, and suspended solids run on the supernatant will measure the side stream load.

ULTIMATE DISPOSAL

*heavy metals
*nutrients
*bacteria
*pH

Land fill is an example of an ultimate disposal process. A land fill operation could have three monitoring locations: the sludge itself; observation wells, and the drainage ditch.

The sludge and monitoring wells should be checked periodically to assure that ground water is not being contaminated. These tests should include heavy metals, nutrients, bacteria and pH.

During periods of rainfall the leachate in the drainage ditch may contaminate surface waters. Testing for bacteria, BOD, pH and nutrients provides monitoring for this problem.

This has been a quick overview of the monitoring and operational tests used with the solids handling processes. More complete descriptions of the tests and their specific application is presented in other modules.

APPENDIX A

Treatment Process	Applicable Tests	Purpose
Chemical Conditioning	Specific Resistance	Process Control
	Capillary Suction Time	" "
	Filter Leaf	" "
	Jar Test	" "
Gravity Thickening	Total Solids	Process Efficiency
	Settleometer	Process Control
	Suspended Solids	Side Stream Load
Gravity Concentration	BOD	" " "
	Jar Test	Process Control
Flotation Thickening	Total Solids	Process Efficiency
	Settleometer	Process Control
	Suspended Solids	Side Stream Load
	BOD	" " "
	Jar Test	Process Control
Aerobic Digestion	Temperature	" "
	pH	" " and Side Stream Characteristics
	Dissolved Oxygen	Process Control
	Settleable Solids (Settleometer)	" "
	Total Solids	Process Efficiency
	Total Volatile Solids	Sludge Stability
	Alkalinity	Process Control
	Suspended Solids	Side Stream Load
	BOC	" " "
Anaerobic Digester	Total Solids	Process Efficiency
	Volatile Suspended Solids	" " and Sludge Stability
	Suspended Solids	Side Stream Load
	BOD	" " "
	pH	Process Control
	Temperature	" "
	Volatile Acids	" "
	Alkalinity	" "
	Methane	" "
Heat Conditioning	Total Solids	Process Efficiency
	Temperature	Process Control
	pH	Side Stream Load
	Suspended Solids	" " "
	BOD	" " "

Treatment Process	Applicable Tests	Purpose
Lime Stabilization	Total Solids	Process Control
	Suspended Solids	Process Efficiency
	pH	Process Control
	Alkalinity	" "
	Volatile Suspended Solids	Sludge Stability
	O_2 Uptake	" "
Chlorine Stabilization	pH	Process Control
	Total Solids	" "
	Suspended Solids	Process Efficiency
	Volatile Suspended Solids	" " and Sludge Stability
	Chlorine Demand	Process Control
	Chlorine Residual	Side Stream Characteristics
	O_2 Uptake	Sludge Stability
Centrifugation	Total Solids	Process Efficiency
	BOD	Side Stream Load
	Suspended Solids	" " "
	Capillary Suction Time	Process Control
Vacuum Filtration	Total Solids	Process Efficiency
	BOD	Side Stream Load
	Suspended Solids	" " "
	Specific Resistance	Process Control
	Capillary Suction Time	" "
	Filter Leaf	" "
Filter Press	Total Solids	Process Efficiency
	BOD	Side Stream Load
	Suspended Solids	" " "
	Specific Resistance	Process Control
	Capillary Suction Time	" "
	Filter Leaf	" "
Belt Filtration	Total Solids	Process Efficiency
	BOD	Side Stream Load
	Suspended Solids	" " "
	Specific Resistance	Process Control
	Capillary Suction Time	" "
	Filter Leaf	" "
Sludge Drying Bed	Total Solids	Process Efficiency
	Specific Resistance	Process Control
	Settleometer	" "

Treatment Process	Applicable Tests	Purpose
Sludge Lagoons	Total Solids	Process Control and Efficiency
	Suspended Solids	Process Efficiency
	Volatile Suspended Solids	Process Efficiency and Sludge Stability
	BOD	Side Stream Load
	Dissolved Oxygen	Process Control
Heat Drying	Total Solids	Process Efficiency
	Temperature	Process Control
Multiple Heat and Incineration	Temperature	" "
	Total Solids	Process Efficiency
	Total Volatile Solids	" "
	Calorific Value	Process Control
	Heavy Metals	Ash Health Monitoring
	Toxic Compounds	" " "
	Stack Gas Analysis	Gas " "
Composting	Temperature	Process Control
	Oxygen	" "
	Bacteriological	Health Monitoring
	Nitrogen	Nutrient Value
	Total Solids	Process Control and Efficiency
Land Application	Heavy Metal	Health Monitoring
	Toxic Compounds	" "
	Bacteriological	" "
	Nitrogen	Nutrient Value
	Phosphorous	" "
	pH	" "
	Total Solids	Process Control
	Volatile Suspended Solids	Sludge Stability
	BOD	" "
	O_2 Uptake	" "
Land Fill	Heavy Metals	Health Monitoring
	Bacteriological	" "
	Toxic Compounds	" "
	Phosphorous	Nutrient Value
	Nitrogen	" "
	pH	" "
	BOD	Stability
	Volatile Suspended Solids	"
	O_2 Uptake	"

References

1. Process Design Manual for Sludge Treatment and Disposal, USEPA, EPA 625/1-79-011, Cincinnati, 1979.

2. Operations Manual; Sludge Handling and Conditioning, USEPA, EPA 430/9-78-002, Washington, D.C., 1978.

3. WPCF Manual of Practice No. 20, Sludge Dewatering, Water Pollution Control Federation, Washington, D.C., 1969.

4. Treatment and Disposal of Wastewater Sludges, P. Aarne Vesilind, Ann Arbor Science, Ann Arbor, 1979.

5. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA-AWWA-WPCF, Washington, D.C., 1981.

WORKSHEET

1. Match the following test descriptions with their name.

_____ a.	Sludge added to a Buchner funnel containing a filter paper.	1. Jar test
_____ b.	Filter medium cover porous disc to which vacuum is applied.	2. Specific resistance test
_____ c.	Flocculation and settling observed in beakers.	3. Leaf test
_____ d.	Time required for liquid to travel 1 cm in a blotter paper.	4. Capillary suction time (CST)

2. Match the following laboratory testing procedures with the major function or purpose in operating sludge treatment and disposal.

____ a.	Jar test	1. To determine dewaterability, filterability and thickening ability.
____ b.	pH	2. To maintain operational control.
____ c.	Total solids	3. To evaluate efficiency of treatment processes.
____ d.	Toxic organic compounds	4. To evaluate and monitor health hazards and biological stability.
____ e.	Heavy metal analysis	5. To measure nutrient value and heat value.
____ f.	Settleometer	
____ g.	Oxygen uptake	
____ h.	Filter Leaf Test	
____ i.	Dissolved oxygen	
____ j.	Suspended solids	
____ k.	Capillary Suction Time	
____ l.	Methane	
____ m.	Calorific value	
____ n.	Alkalinity	
____ o.	Volatile suspended solids	
____ p.	Specific resistance test	
____ q.	BOD, COD	
____ r.	Bacteriological Analysis	
____ s.	% Solids	
____ t.	Volatile acids	

____ u. Phosphorous

____ v. Centrifuge

____ w. Total Organic Carbon

____ x. Nitrogen